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INFLATABLE SIDE CURTAIN

Related Applications

This application is a continuation-in-part of U.S. Patent Application Serial No. __/_____, filed September 5, 2001, which is a continuation of U.S. Patent Application Serial No. 09/672,547, filed September 28, 2000, now abandoned.

Field of the Invention

The present invention relates to an apparatus for helping to protect an occupant of a vehicle in the event of a side impact to the vehicle and/or a vehicle rollover.

Background of the Invention

It is known to inflate an inflatable vehicle occupant protection device to help protect a vehicle occupant in the event of a vehicle collision. One particular type of inflatable vehicle occupant protection device is an inflatable curtain that inflates from the roof of the vehicle downward inside the passenger

compartment in the event of a side impact or a vehicle rollover. The inflatable curtain, when inflated, is positioned between a vehicle occupant and the side structure of the vehicle. A known inflatable curtain is inflated by inflation fluid directed from an inflator into the inflatable curtain through a fill tube.

Summary of the Invention

The present invention relates to an apparatus for helping to protect an occupant of a vehicle that has a side structure and a roof. The apparatus comprises an inflatable vehicle occupant protection device inflatable into a position between the side structure of the vehicle and a vehicle occupant. The inflatable vehicle occupant protection device includes a forwardmost inflatable chamber. The inflatable vehicle occupant protection device is rolled up in an outboard direction into a stored position. An inflation fluid source provides inflation fluid for inflating the inflatable vehicle occupant protection device for at least five seconds.

The inflatable vehicle occupant protection device is adapted to inflate and unroll in a downward direction away from the vehicle roof. A first portion of the inflatable vehicle occupant protection device is adapted

to engage an occupant's head positioned against the side structure of the vehicle. The first portion moves the occupant's head laterally in the vehicle away from the side structure and inflates between the side structure of the vehicle and the occupant's head.

5 The present invention also relates to a method for helping to protect an occupant of a vehicle that has a side structure and a roof, in which a head of the occupant is positioned against the vehicle side structure. The method includes the step of providing an inflatable vehicle occupant protection device that is inflatable into a position between the side structure of the vehicle and a vehicle occupant. The inflatable vehicle occupant protection device includes inflatable first and second portions. The first portion is the forwardmost positioned inflatable portion of the inflatable vehicle occupant protection device. The method also includes the step of providing an inflation fluid source that provides inflation fluid for inflating the inflatable vehicle occupant protection device and maintaining the inflatable vehicle occupant protection device in an inflated condition for at least five seconds.

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of the following description of the invention with reference to the accompanying drawings, in which:

Fig. 1 is a schematic view of an apparatus for helping to protect a vehicle occupant illustrating the apparatus in a deflated condition, according to a first embodiment of the invention;

Fig. 2 is a schematic view of the apparatus of Fig. 1 in an inflated condition;

Fig. 3 is a sectional view of the apparatus taken generally along line 3-3 in Fig. 2;

Fig. 4 is a schematic view of a portion of the apparatus of Figs. 1-3;

Fig. 5A is a schematic view of the apparatus of Figs. 1-4 prior to actuation of the apparatus;

Fig. 5B is a sectional view taken generally along line 5B-5B in Fig. 5A;

Fig. 6A is a schematic view of the apparatus of Figs. 1-4 at a first interval after actuation of the apparatus;

Fig. 6B is a sectional view taken generally along line 6B-6B in Fig. 6A;

Fig. 7A is a schematic view of the apparatus of Figs. 1-4 at a second interval after actuation of the apparatus;

5 Fig. 7B is a sectional view taken generally along line 7B-7B in Fig. 7A;

Fig. 7C is a sectional view taken generally along line 7C-7C in Fig. 7A;

Fig. 7D is a schematic perspective view of a portion of the apparatus of Fig 7A;

10 Fig. 8A is a schematic view of the apparatus of Figs. 1-4 at a third interval after actuation of the apparatus;

Fig. 8B is a sectional view taken generally along line 8B-8B in Fig. 8A;

15 Fig. 9 is a schematic view of a portion of an apparatus for helping to protect a vehicle occupant illustrating the apparatus in an inflated condition, according to a second embodiment of the invention; and

20 Fig. 10 is a schematic view of a portion of an apparatus for helping to protect a vehicle occupant illustrating the apparatus in an inflated condition, according to a third embodiment of the invention.

Description of Preferred Embodiments

As representative of the present invention, an apparatus 10 helps to protect an occupant of a vehicle 12. As shown in Figs. 1 and 2, the apparatus 10 includes an inflatable vehicle occupant protection device in the form of an inflatable curtain 14 that is mounted adjacent the side structure 16 of the vehicle 12 and a roof 18 of the vehicle. The roof 18 may be either a standard roof that is fixed in place or a convertible roof that can be moved or removed. The side structure 16 of the vehicle 12 includes side windows 20. An inflator 24 is connected in fluid communication with the inflatable curtain 14 through a fill tube 22.

The fill tube 22 has a first end portion 30 for receiving fluid from the inflator 24. The fill tube 22 has a second end portion 32 disposed in the inflatable curtain 14. The second end portion 32 of the fill tube 22 has a plurality of openings (not shown) that provide fluid communication between the fill tube 22 and the inflatable curtain 14. As shown in Figs. 1 and 2, the second end portion 32 may include an angled portion 34 that extends at an acute angle from the remainder of the fill tube 22.

5 The inflator 24 is actuatable to provide inflation
fluid for inflating the inflatable curtain 14 and
maintaining the curtain in an inflated condition for at
least five seconds. The inflator 24 preferably contains
a stored quantity of pressurized inflation fluid (not
shown) in the form of a gas to inflate the inflatable
curtain 14. The inflator 24 alternatively could contain
a combination of pressurized inflation fluid and
ignitable material for heating the inflation fluid, or
10 could be a pyrotechnic inflator that uses the combustion
of gas-generating material to generate inflation fluid.
As a further alternative, the inflator 22 could be of any
suitable type or construction for supplying a medium for
inflating the inflatable curtain 14 and maintaining the
15 curtain in an inflated condition for at least five
seconds.

20 The apparatus 10 includes a housing 26 (Fig. 1) that
stores the inflatable curtain 14 in a deflated condition.
The fill tube 22, the deflated inflatable curtain 14, and
housing 26 have an elongated configuration and extend
along the vehicle roof 18 and along the side structure 16
of the vehicle 12 above the side windows 20. According
to the present invention, the inflatable curtain 14 is

placed in a stored position in the housing 26 by rolling
up the curtain in an outboard roll direction. The lower
edge 52 of the inflatable curtain 14 is rolled in an
outboard direction toward the vehicle side structure 16
5 about an axis that extends generally parallel to the
lower edge of the curtain. The stored position in which
the inflatable curtain 14 is rolled up in the outboard
direction is best illustrated in Fig. 5b.

Referring to Fig. 3, the inflatable curtain 14
10 comprises first and second panels 40 and 42 that are
arranged in an overlying manner. The first and second
panels 40 and 42 are interconnected to form a perimeter
connection 46 (Figs. 2 and 3) that extends along a
perimeter 48 of the panels. The first and second panels
15 40 and 42 are also interconnected to form connections 70
within the perimeter 48 of the inflatable curtain 14.

In a preferred construction of the inflatable
curtain 14, the perimeter connection 46 and the
connections 70 are formed by weaving the panels 40 and 42
20 together. In alternative constructions of the inflatable
curtain 14, means such as stitching, dielectric sealing,
ultrasonic bonding, heat sealing, and adhesives may be
used to interconnect the first and second panels 40 and

42 in order to form the perimeter connection 46 and the connections 70.

In the preferred construction of the inflatable curtain 14, the curtain is formed by weaving the first and second panels 40 and 42 simultaneously while also interweaving the perimeter connection 46 and the connections 70 as single layers of fabric. This can be accomplished by using a Jacquard or Dobby weaving machine. The weaving machines are pre-programmed to weave the first and second panels 40 and 42 along with the perimeter connection 46 and connections 70 at the same time. No intermediate steps are required.

In an alternative construction of the inflatable curtain 14, the curtain may be formed by interconnecting two separate fabric pieces together along the perimeter connection 46 and the connections 70. As a further alternative, a single piece of fabric may be folded over to form the overlying first and second panels 40 and 42. In this latter alternative, the fold is part of the perimeter connection 46 of the inflatable curtain 14.

Preferably, the inflatable curtain 14 is constructed of a woven fabric, such as nylon, that is coated with a gas impermeable material, such as urethane or silicone.

The inflatable curtain 14 thus may have a substantially gas-tight construction. Other materials, such as elastomers, plastic films, or combinations thereof, may also be used to construct the inflatable curtain 14, in which case the curtain may have a non-woven construction. The materials used to construct the inflatable curtain 14 may also be single or multi-layered materials.

The first and second panels 40 and 42, the perimeter connection 46, and the connections 70 may be coated using a laminate film, slurry, and/or a spray coating, such as silicone, urethane, or other known suitable materials, in order to achieve a substantially gas-tight construction. This helps to prevent gas from permeating directly through the first and second panels 40 and 42, the perimeter connection 46, and the connections 70.

The perimeter 48 (Fig. 2) of the inflatable curtain 14 is defined by upper and lower edges 50 and 52, respectively, of the curtain and front and rear edges 54 and 56, respectively, of the curtain that are spaced apart horizontally along the upper and lower edges. The perimeter connection 46 (Fig. 2) defines an inflatable volume 60 of the inflatable curtain 14.

The front and rear edges 54 and 56 of the inflatable curtain 14 partially define front and rear portions 62 and 64, respectively, that are spaced apart horizontally along the upper and lower edges 50 and 52 and extend
5 between the upper and lower edges. A middle portion 66 of the inflatable curtain 14 is positioned between the front and rear portions 62 and 64 of the inflatable curtain 14 and extends between the upper and lower edges 50 and 52 of the curtain.

10 As illustrated in Fig. 2, the front and rear edges 54 and 56 extend between the upper and lower edges 50 and 52. The front and rear edges 54 and 56 could, however, be omitted and the upper and lower edges 50 and 52 could be curved and extended until they intersect, in which
15 case the front and rear portions 58 and 60 would be partially defined by the intersecting upper and lower edges.

Referring to Fig. 4, the inflatable curtain 14 includes four middle connections 80 located in the middle
20 portion 66 of the curtain. The middle connections 80 are generally arc-shaped, concentric, and are positioned facing concavely downward, as viewed in Fig. 4, toward the lower edge 52 of the inflatable curtain 14. A first

middle connection 82 includes a generally T-shaped portion 84 that extends towards the upper edge 50 of the inflatable curtain 14 from a position proximate the apex of the arc-shaped first middle connection. The portion 84 may include an aperture 86 for receiving a fastening device 88 (Fig. 2), such as a clamp, for connecting the inflatable curtain 14 and the fill tube 22 to the vehicle 12.

The middle connections 80 help to define three inflatable middle chambers 100 located in the middle portion 66 of the inflatable curtain 14. The middle chambers 100 are generally arc-shaped, concentric, and are positioned facing concavely downward, as viewed in Fig. 4, toward the lower edge 52 of the inflatable curtain 14.

The inflatable curtain 14 also includes a front connection 110 located in the front portion 62 of the curtain. The front connection 110 includes an upper end portion 112, a lower end portion 114 and a middle portion 116 that extends between the upper and lower end portions. The upper end portion 112 is positioned near the upper edge 50 of the inflatable curtain 14 and extends generally parallel to the upper edge of the

curtain. The upper end portion 112 may include an aperture (not shown) for receiving a fastening device. The lower end portion 114 is positioned near the lower edge 52 of the inflatable curtain 14 and extends generally parallel to the lower edge of the curtain towards the middle portion 66 of the curtain. The middle portion 116 of the front connection 110 is curved and extends generally diagonally between the upper and lower end portions 112 and 114.

The front connection 110, perimeter connection 46, and the first middle connection 82 help to define two inflatable front chambers 120 located in the front portion 62 of the inflatable curtain 14. The front chambers 120 extend generally diagonally from near the upper edge 50 of the inflatable curtain 14 to near the lower edge 52 of the curtain. The front chambers 120 include a forwardmost chamber 122 partially defined by the perimeter connection 46 and the front connection 110. The forwardmost chamber 122 is located forward of all of the remaining inflatable chambers of the inflatable curtain 14.

The inflatable curtain 14 also includes a rear connection 140 located in the rear portion 64 of the

curtain. The rear connection 140 includes an upper end portion 142, a lower end portion 144 and a middle portion 146 that extends between the upper and lower end portions. The upper end portion 142 is positioned near
5 the upper edge 50 of the inflatable curtain 14 and extends generally parallel to the upper edge of the curtain. The upper end portion 142 may include an aperture (not shown) for receiving a fastening device. The lower end portion 144 is positioned near the lower
10 edge 52 of the inflatable curtain 14 and extends generally parallel to the lower edge of the curtain towards the middle portion 66 of the curtain. The middle portion 146 of the rear connection 140 is curved and extends generally diagonally between the upper and lower
15 end portions 142 and 144.

The rear connection 140, perimeter connection 46, and the first middle connection 82 help to define two inflatable rear chambers 150 located in the rear portion 64 of the inflatable curtain 14. The rear chambers 150
20 extend from near the upper edge 50 of the inflatable curtain 14 to near the lower edge 52 of the curtain. The rear chamber 150 adjacent the middle portion 66 extends generally diagonally, whereas the rear chamber adjacent

the rear edge 56 extends in a generally curved manner. The rear chambers 150 include a rearwardmost chamber 152 partially defined by the perimeter connection 46 and the rear connection 140. The rearwardmost chamber 152 is located rearward of all of the remaining inflatable chambers of the inflatable curtain 14.

The front connection 110, middle connections 80 and rear connection 140 help define an inflatable bottom chamber 160 that extends along the length of the inflatable curtain 14 between the lower edge 52 and the connections. The bottom chamber 160 provides fluid communication between the front chambers 120, middle chambers 100, and rear chambers 150. The forwardmost chamber 122 includes a passage 162 that provides fluid communication between the forwardmost chamber and the bottom chamber 160. The rearwardmost chamber 152 includes a passage 164 that provides fluid communication between the rearwardmost chamber and the bottom chamber 160.

As illustrated in Figs. 2 and 4, the inflatable curtain 14 may include a pocket 200 for receiving the angled portion 34 of the second end portion 32 of the fill tube 22. The pocket 200 is defined by a portion of

the perimeter connection 46 adjacent the intersection of the front edge 54 and the upper edge 50 of the inflatable curtain 14. The pocket 200 surrounds the angled portion 34 of the fill tube 22 and forms a snug fit with the fill tube. The pocket 200 thus may help to position the fill tube 22 in the inflatable curtain 14 and helps to maintain the position of the fill tube relative to the curtain.

The inflatable curtain 14 may also include an opening 202 for supporting the first end portion 30 of the fill tube 22. The opening 202 is positioned adjacent the intersection of the rear edge 56 and the upper edge 50 of the inflatable curtain 14. The opening 202 is defined by portions of the perimeter connection 46 adjacent the intersection of the upper edge 50 and the rear edge 52 of the inflatable curtain 14. The opening 202 receives the fill tube 22 when the fill tube is inserted into the inflatable curtain 14. When the fill tube 22 is fully inserted in the inflatable curtain 14, the portions of the curtain that define the opening 202 encircle the first end portion 30 of the fill tube 22 and form a snug fit with the fill tube. The opening 202 thus may help to position the fill tube 22 in the inflatable

curtain 14 and helps to maintain the position of the fill tube relative to the curtain.

The upper end portions 112 and 142 of the front and rear connections 110 and 140 may be spaced apart from the upper edge 50 of the inflatable curtain 14 a distance that is preferably slightly larger than the diameter of the fill tube 22. The upper end portions 112 and 142 thus may help guide the fill tube 22 into the inflatable curtain 14 when the tube is inserted into the curtain.

The upper end portions 112 and 142 also may help to position the fill tube 22 in the inflatable curtain 14 and help to maintain the position of the fill tube relative to the curtain.

The vehicle 12 includes a sensor mechanism 210 (shown schematically in Figs. 1 and 2) for sensing a side impact to the vehicle 12 and/or a rollover of the vehicle 12. The sensor mechanism 210 actuates the inflator 24 in response to the sensing of a side impact or a vehicle rollover.

In the event of a rollover of the vehicle 12 or a side impact to the vehicle for which inflation of the inflatable curtain 14 is desired, the sensor mechanism 210 provides an electrical signal over lead wires 212 to

the inflator 24. The electrical signal causes the inflator 24 to be actuated in a known manner. The inflator 24 discharges fluid under pressure into the fill tube 22. The fill tube 22 directs the fluid into the inflatable curtain 14.

The inflatable curtain 14 inflates under the pressure of the inflation fluid from the inflator 24. The housing 26 (Fig. 1) opens and the inflatable curtain 14 (Fig. 2) inflates and unrolls in a direction away from the roof 18 in a downward direction as shown in the drawings and in a downward direction with respect to the direction of forward travel of the vehicle 12 into the inflated condition illustrated in Fig. 2.

The inflatable curtain 14, when inflated, extends along the side structure 16 of the vehicle 12 and is positioned between the side structure and any occupant of the vehicle. When the inflatable curtain 14 is in the inflated condition, the first panel 40 (Fig. 3) is positioned adjacent the side structure 16 of the vehicle 12. The upper edge 50 (Fig. 2) of the inflatable curtain 14 is positioned adjacent the intersection of the roof 18 and the side structure 16 of the vehicle 12. The front edge 54 of the inflatable curtain 14 is positioned

adjacent an A pillar 220 of the vehicle 12. The rear
edge 56 of the inflatable curtain 14 is positioned
adjacent a C pillar 222 of the vehicle 12. The
inflatable curtain 14 extends between the A pillar 220
5 and the C pillar 222 of the vehicle 12 and overlies at
least a portion of the A pillar, C pillar, and a B pillar
224 of the vehicle.

It will be recognized by those skilled in the art
that the inflatable curtain may have alternative
10 configurations. For example, in the illustrated
embodiment, the inflatable curtain 14 extends between the
A pillar 220 and the C pillar 222 of the vehicle 12. The
inflatable curtain 14 could, however, extend between the
A pillar 220 and the B pillar 224 only or between the B
15 pillar and the C pillar 222 only. Also, the inflatable
curtain 14 could extend between the A pillar 220 and a D
pillar 226 of the vehicle.

As the inflatable curtain 14 is inflated, inflation
fluid is directed from the fill tube 22 into the front
20 and rear chambers 120 and 150. In the embodiment
illustrated in Figs. 1-4, the inflation fluid begins to
inflate the front and rear chambers 120 and 150 before
the middle chambers 100 begin to inflate. In fact, the

front and rear chambers 120 and 150 may be substantially inflated before the middle chambers 100 begin to inflate. Thus, in the embodiment of Figs. 1-4, the front and rear portions 62 and 64 of the inflatable curtain 14 are
5 inflated before the middle portion 66 of the curtain is inflated.

As the inflatable curtain 14 is inflated, inflation of the front and rear portions 62 and 64 causes the curtain to move in the downward direction away from the
10 vehicle roof 18. Inflation of the front and rear portions 62 and 64 causes the front, middle and rear portions to deploy substantially evenly along the length of the inflatable curtain 14. The lower edge 52 of the inflatable curtain 14 is thus deployed substantially
15 evenly long the length of the curtain.

Those skilled in the art will recognize that an occupant of the vehicle may be positioned against the vehicle side structure 16 at the time the inflatable curtain 14 is inflated. This is illustrated in Fig. 5B.
20 As shown in Fig. 5B, the head 250 of a vehicle occupant 252 is positioned against the vehicle side structure 16. In particular, the occupant's head 250 is positioned against a side window 20 of the vehicle.

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According to the present invention, the construction of the inflatable curtain 14 and the manner in which the curtain is placed in the stored position helps to inflate the curtain between the vehicle occupant and the vehicle side structure 16 when the occupant 252 is positioned against the side structure at the time of inflation. In particular, the construction of the front chambers 120, middle chambers 100, rear chambers 150, and bottom chamber 160, in conjunction with the outboard roll by which the curtain is placed in the stored position, helps to inflate the curtain between the vehicle occupant and the vehicle side structure 16.

According to the present invention, the forwardmost chamber 122 and the rearwardmost chamber 152 are among the chambers initially inflated upon actuation of the inflator 24. Some or all of the remaining front chambers 120, middle chambers 100, and rear chambers 150 may also be initially inflated along with the forwardmost and rearwardmost chambers 122 and 152 upon actuation of the inflator 24. In the embodiment illustrated in Figs. 1-4, the forwardmost and rearwardmost chambers 122 and 152 are initially inflated along with the remaining front and rear chambers 120 and 150. As stated above, the middle

chambers 100 are inflated subsequent to inflation of the front and rear chambers 120 and 150.

Referring to Figs. 5A and 5B, the apparatus 10 is illustrated prior to actuation of the inflator 24. A front seat occupant 252 is positioned in a front seat 254 of the vehicle 12 and a rear seat occupant 262 is positioned in a rear seat 264 of the vehicle. The head 250 of the front seat occupant 252 is positioned against a side window 20 of the vehicle side structure 16. This is best illustrated in Fig. 5B. The head 260 (Fig. 5A) of the rear seat occupant 262 is positioned against a side window 20 of the vehicle side structure 16. The occupant's heads 250 and 260, however, could be positioned against other parts of the side structure 16, such as the B pillar 224 or C pillar 222, respectively. Although the rear seat occupant 262 is not illustrated in Fig. 5B, it will be appreciated that the position of the rear seat occupant may be identical or substantially similar to the position of the front seat occupant 252.

The apparatus 10 is illustrated in Fig. 5B in the stored position in which the inflatable curtain 14 is rolled up in the outboard direction and placed in the housing 26. In Fig. 5B, certain parts of the vehicle 12

have been omitted for clarity. For example, the vehicle 12 may include a headliner (not shown), which could extend along the roof 18 and overlies the roof and the apparatus 10 when the apparatus is in the stored position.

Preferably, the inflatable curtain 14 has an angled orientation relative to the vehicle side structure 16 and relative to a vertical direction in the vehicle 12. In the embodiment illustrated in Fig. 5B, the inflatable curtain 14 is positioned along a centerline 256 that extends transverse to the vehicle side structure 16 and to a vertical direction indicated generally by the line labeled 258. Preferably, the angle between the centerline 256 and the line 258 is about thirty degrees. The centerline 256 could, however, extend at some other angle relative to the line 258. The angle between the centerline 256 and the line 258 depends partially on vehicle space limitations and the architecture of the vehicle 12.

Referring to Figs. 6A and 6B, upon actuation of the inflator 24, the housing 26 opens and the inflatable curtain begins to inflate in the downward direction away from the vehicle roof 18. The downward direction

preferably extends generally along the centerline 256 such that the inflatable curtain 14 inflates at an acute angle towards the vehicle side structure 16. The inflatable curtain 14 could, however, inflate at some other angle or vertically in the vehicle 12 depending on the orientation of the curtain relative to the vehicle. As the inflatable curtain 14 is inflated, the curtain unrolls in an outboard direction. The front connection 110 (Fig. 4) helps direct inflation fluid into the forwardmost chamber 122 and the rear connection 140 helps direct inflation fluid into the rearwardmost chamber 152. When the inflatable curtain 14 inflates a given distance in the downward direction, the curtain comes into contact with the front seat occupant's head 250 and the rear seat occupant's head 260. This is illustrated in Figs. 6A and 6B.

Referring to Figs. 7A-7D, as the inflatable curtain 14 continues to inflate, respective portions 270 and 272 of the curtain come into contact with the occupants' heads 250 and 260 and are blocked against deployment in the downward direction. In the embodiment illustrated in Figs. 7A-7D, the portion 270 includes portions of the front chambers 120 and middle chambers 100. The portion

272 includes portions of the rear chambers 150, and the middle chambers 100. The portions 270 and 272, however, include only a small portion of the forwardmost and rearwardmost chambers 122 and 152, respectively. The forwardmost chamber 122 and the rearwardmost chamber 152 are thus substantially free from being blocked against deployment in the downward direction by the occupants' heads 250 and 260. When the portions 270 and 272 contact the occupants' heads 250 and 260 and are blocked against downward movement, the forwardmost chamber 122 and the rearwardmost chamber 152 continue to inflate and deploy in the downward direction, vertically below the top of the occupants' heads 250 and 260, respectively.

As the inflatable curtain 14 continues to inflate and unroll, the portions 270 and 272 are urged in the outboard direction towards the vehicle side structure 16. The portions 270 and 272 are urged to move in the outboard direction toward the vehicle side structure 16 by the inflation of the forwardmost and rearwardmost chambers 122 and 152 in the downward direction along the centerline 256 and by the inflatable curtain 14 unrolling in the outboard direction. The portions 270 and 272 unroll in the outboard direction and roll over or move

around the occupants' heads 250 and 260 towards the vehicle side structure 16. The portions 270 and 272 engage the occupants' heads 250 and 260 and the vehicle side structure 16 at or near respective locations 274 and 276 where the occupants' heads engage the side structure 16. This is best illustrated in Fig. 7C. The locations 274 and 276 form a space between the occupants' heads 250 and 260 and the side structure 16 having a generally concave arrangement facing upward in the vehicle 12 towards the vehicle roof 18.

The forwardmost chamber 122 (Figs. 7A-7D), inflating downwardly and unrolling in an outboard direction, and being positioned in front of and vertically below the top of the front seat occupant's head 250, urges the portion 270 into the location 274, thus forcing or wedging the portion 270 between the front seat occupant's head and the vehicle side structure 16. This helps to resist movement of the inflatable curtain 14 away from the side structure 16 of the vehicle 12 and thus helps to prevent the curtain from inflating inboard of the front seat occupant 252.

The rearwardmost chamber 152, inflating downwardly and unrolling in an outboard direction, and being

positioned rearward of and vertically below the top of the rear seat occupant's head 260, urges the portion 272 into the location 276, thus forcing or wedging the portion 272 between the rear seat occupant's head and the vehicle side structure 16. This helps to resist movement of the inflatable curtain 14 away from the side structure 16 of the vehicle 12 and thus helps to prevent the curtain from inflating inboard of the rear seat occupant 262.

As the inflatable curtain 14 continues to inflate and unroll, the curtain continues to move in the downward direction. The portions 272 and 274 of the inflating curtain 14, being forced or wedged between the occupants' heads 250 and 260 and the vehicle side structure 16, moves the occupants' heads away from the side structure. The forwardmost and chamber 122, inflating in front of the front seat occupant's head 250 is substantially unobstructed from deployment. The rearwardmost and chamber 152, inflating rearward of the rear seat occupant's head 250, is substantially unobstructed from deployment. The forwardmost and rearwardmost chambers 122 and 152, being substantially unobstructed from deployment, allow substantially unobstructed flow of

inflation fluid through the passages 162 and 164,
respectively, into the bottom chamber 160. The bottom
chamber 160 may thus be inflated rearwardly from the
forwardmost chamber 122 between the front seat occupants'
5 head 250 and the vehicle side structure 16 and thus may
help move the front seat occupant's head laterally in the
vehicle away from the side structure. Also, the bottom
chamber 160 may be inflated forwardly from the
rearwardmost chamber 152 between the rear seat occupants'
10 head 260 and the vehicle side structure 16 and thus may
help move the rear seat occupant's head laterally in the
vehicle away from the side structure. The inflatable
curtain 14 is thus deployed into the inflated condition
wherein the curtain is positioned between the front and
15 rear seat occupants 252 and 262 and the vehicle side
structure 16. This is illustrated in Figs. 8A and 8B.

The inflatable curtain 14, when in the inflated
condition of Figs. 8A and 8B, helps to protect the front
and rear seat occupants 252 and 262 in the event of a
20 vehicle rollover or a side impact to the vehicle 12. The
connections 70 help to limit the thickness of the
inflated inflatable curtain 14 and help to reduce the
overall volume of the curtain. The front chambers 120,

middle chambers 100, and rear chambers 150, when inflated, help to absorb the energy of impacts with the inflatable curtain 14 and help to distribute the impact energy over a large area of the curtain. The inflatable curtain 14 is maintained in the inflated condition for at least five seconds, which helps to ensure that the curtain will remain inflated throughout the duration of a side impact and/or a vehicle rollover.

Those skilled in the art will recognize that the front chambers 120, rear chambers 150, and middle chambers 100 of the inflatable curtain 14 may be defined by connections 70 having shapes and configurations different than those illustrated in Figs. 1-8. Examples of inflatable curtains 14 having connections 70 with different shapes and configurations are illustrated in the embodiments of Figs. 9 and 10.

A second embodiment of the present invention is illustrated in Fig. 9. The second embodiment of the invention is similar to the first embodiment of the invention illustrated in Figs. 1-8. Accordingly, numerals similar to those of Figs. 1-8 will be used in Fig. 9 to identify similar components, the suffix letter "a" being associated with the numerals of Fig. 9 to avoid

confusion. The inflatable curtain 14a (Fig. 9) of the second embodiment includes connections 70a that have different configurations than the connections 70 (Figs. 1-8) of the first embodiment.

5 As illustrated in Fig. 9, the inflatable curtain 14a includes a first connection 300 positioned generally in the front portion 62a of the curtain. The first connection 300 has a linear, generally horizontally arranged central portion and opposite drop-shaped end portions 302. A second connection 304 positioned 10 generally in the middle portion 66a and rear portion 64a forms a non-inflatable portion 306 of the inflatable curtain 14a. A generally round third connection 310 is positioned in the rear portion 64a of the inflatable 15 curtain 14a. The forwardmost chamber 122a is partially defined by the first connection 300 and the front edge 54a of the inflatable curtain 14a. The rearwardmost chamber 152a is partially defined by the second and third connections 304 and 310 and the rear edge 56a of the 20 inflatable curtain 14a. The inflatable curtain 14a, prior to inflation, is placed in the stored position, i.e., rolled up in the outboard direction, in a manner

identical to the inflatable curtain of the first embodiment.

As the inflatable curtain 14a is inflated, inflation fluid is directed from the fill tube (not shown) into the front portion 62a, rear portion 64a, and middle portion 66a. The forwardmost chamber 122a and the rearwardmost chamber 152a are initially inflated upon actuation of the inflator (not shown). The inflatable curtain 14a deploys generally evenly along the length of the curtain. The inflatable curtain 14a inflates in the downward direction and unrolls in the outboard direction, between the side structure of the vehicle and the vehicle occupants (not shown) in a manner similar or identical to the manner discussed above in regard to the inflatable curtain of the first embodiment.

As the inflatable curtain 14a inflates and unrolls in the downward direction and the outboard direction, the curtain is urged in the outboard direction towards the vehicle side structure (not shown). The inflatable curtain 14a is urged in the outboard direction towards the vehicle side structure 16 by the inflation of the forwardmost and rearwardmost chambers 122a and 152a and by the unrolling of the inflatable curtain 14a in the

outboard direction. The inflatable curtain 14a unrolls in the outboard direction and rolls over or moves around the occupants' heads (not shown) towards the vehicle side structure.

5 The forwardmost chamber 122a, inflating downwardly and unrolling in an outboard direction, and being positioned in front of and vertically below the top of the front seat occupant's head, forces or wedges the inflatable curtain 14a between the front seat occupant's
10 head and the vehicle side structure. This helps to resist movement of the inflatable curtain 14a away from the side structure of the vehicle and thus helps to prevent the curtain from inflating inboard of the front seat occupant.

15 The rearwardmost chamber 152a, inflating downwardly and unrolling in an outboard direction, and being positioned rearward of and vertically below the top of the rear seat occupant's head, forces or wedges the inflatable curtain 14a between the rear seat occupant's
20 head and the vehicle side structure. This helps to resist movement of the inflatable curtain 14a away from the side structure of the vehicle and thus helps to

occupant's head away from the side structure. The inflatable curtain 14a is thus deployed into the inflated condition wherein the curtain is positioned between the front and rear seat occupants and the vehicle side structure.

The inflating curtain 14a thus moves the occupants' heads away from the vehicle side structure and the curtain inflates between the occupants and the vehicle side structure. The inflatable curtain 14a, when inflated, helps to protect the vehicle occupants in the event of a vehicle rollover or a side impact to the vehicle. The connections 70a help to limit the thickness of the inflated inflatable curtain 14a and help to reduce the overall volume of the curtain. The front chamber 120a, middle chamber 100a, and rear chamber 150a, when inflated, help to absorb the energy of impacts with the inflatable curtain 14a and help to distribute the impact energy over a large area of the curtain.

A third embodiment of the present invention is illustrated in Fig. 10. The third embodiment of the invention is similar to the first embodiment of the invention illustrated in Figs. 1-8. Accordingly, numerals similar to those of Figs. 1-8 will be used in

Fig. 10 to identify similar components, the suffix letter "b" being associated with the numerals of Fig. 10 to avoid confusion. The inflatable curtain 14b (Fig. 10) of the third embodiment includes connections 70b that have different configurations than the connections 70 (Figs. 1-8) of the first embodiment.

As illustrated in Fig. 10, the inflatable curtain 14b includes a first connection 320 positioned generally in the front portion 62b of the curtain. The first connection 320 has a diagonally extending central portion 322 and first and second opposite end portions 324 and 326, respectively. The first end portion 324 is positioned near the upper edge 50b of the inflatable curtain 14b and includes an aperture 86b. The second end portion 326 is spaced from and extends generally parallel to the lower edge 52b of the inflatable curtain 14b.

The inflatable curtain 14b includes a second connection 330 positioned generally in the middle portion 66b of the curtain. The second connection 330 has a diagonally extending central portion 332 and first and second opposite end portions 334 and 336, respectively. The first end portion 334 is positioned near the upper edge 50b of the inflatable curtain 14b and includes an

aperture 86b. The second end portion 336 is spaced from and extends generally parallel to the lower edge 52b of the inflatable curtain 14b.

The inflatable curtain 14b includes a third
5 connection 340 positioned generally in the middle portion 66b and rear portion 64b of the curtain. The third connection 340 forms a non-inflatable portion 342 of the inflatable curtain 14a. The third connection 340
10 includes an upper portion 344 including an aperture 86a and an end portion 346 extending in a generally vertical direction.

The inflatable curtain 14b includes a fourth
15 connection 350 positioned generally in the rear portion 64b of the curtain. The fourth connection 350 has a first end portion 352 that intersects the rear edge 56b of the inflatable curtain 14b at the intersection of the rear edge 56b and the opening 202b. The fourth
20 connection 350 has a generally drop-shaped second end portion 354 positioned opposite the first end portion 352. The second end portion 354 is positioned near the intersection of the rear edge 56b and the lower edge 52b of the inflatable curtain 14b.

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The forwardmost chamber 122b is partially defined by the first connection 320 and the front edge 54b of the inflatable curtain 14a. The rearwardmost chamber 152b is partially defined by the third and fourth connections 340 and 350. In the embodiment illustrated in Fig. 10, the inflatable curtain 14b includes a fold-out chamber 360, partially defined by the fourth connection 350, positioned rearward of the rearwardmost chamber 152b. The fold-out chamber 360, however, is folded over along the fold line indicated at 362 such that the fold-out chamber overlies the remainder of the inflatable curtain 14b prior to rolling up the curtain into the stored position. The fold-out chamber 362 remains in this folded over position until the inflatable curtain 14b is substantially inflated. Thus, prior to inflation and for a substantial portion of the period of time during which the inflatable curtain 14b is inflated, the rearwardmost chamber 152b is the chamber positioned at the rearwardmost extent of the inflatable curtain 14b.

As the inflatable curtain 14b is inflated, inflation fluid is directed from the fill tube (not shown) into the front portion 62b, rear portion 64b, and middle portion 66b. The forwardmost chamber 122b and the rearwardmost

chamber 152b are initially inflated upon actuation of the inflator (not shown). The inflatable curtain 14b inflates generally evenly along the length of the curtain. The inflatable curtain 14b inflates in the downward direction and unrolls in the outboard direction between the side structure of the vehicle and the vehicle occupants (not shown) in a manner similar or identical to the manner discussed above in regard to the inflatable curtain of the first embodiment. The fold-out chamber 360 unfolds from the folded over position after the inflatable curtain 14b is substantially inflated between the side structure of the vehicle and the vehicle occupant.

As the inflatable curtain 14b inflates and unrolls in the downward direction and the outboard direction, the curtain is urged in the outboard direction towards the vehicle side structure (not shown). The inflatable curtain 14b is urged in the outboard direction towards the vehicle side structure 16 by the inflation of the forwardmost and rearwardmost chambers 122b and 152b and by the unrolling of the curtain in the outboard direction. The inflatable curtain 14b unrolls in the outboard direction and rolls over or moves around the

occupants' heads (not shown) towards the vehicle side structure.

5 The forwardmost chamber 122b, inflating downwardly and unrolling in an outboard direction, and being positioned in front of and vertically below the top of the front seat occupant's head, forces or wedges the inflatable curtain 14b between the front seat occupant's head and the vehicle side structure. This helps to resist movement of the inflatable curtain 14b away from the side structure of the vehicle and thus helps to prevent the curtain from inflating inboard of the front seat occupant.

10 The rearwardmost chamber 152b, inflating downwardly and in an outboard direction, and being positioned rearward of and vertically below the top of the rear seat occupant's head, forces or wedges the inflatable curtain 14b between the rear seat occupant's head and the vehicle side structure. This helps to resist movement of the inflatable curtain 14b away from the side structure of the vehicle and thus helps to prevent the curtain from inflating inboard of the rear seat occupant.

20 As the inflatable curtain 14b continues to inflate and unroll, the curtain continues to move in the downward

direction. The inflatable curtain 14b moves the occupants' heads laterally in the vehicle away from the vehicle side structure. The forwardmost and chamber 122b, inflating in front of the front seat occupant's head is substantially unobstructed from deployment. The rearwardmost and chamber 152b, inflating rearward of the rear seat occupant's head, is substantially unobstructed from deployment. The forwardmost and rearwardmost chambers 122b and 152b, being substantially unobstructed from deployment, allow substantially unobstructed flow of inflation fluid through the chambers. The inflatable curtain 14b thus may be inflated rearwardly from the forwardmost chamber 122b between the front seat occupants' head and the vehicle side structure and thus may help move the front seat occupant's head away from the side structure. The inflatable curtain 14b may also be inflated forwardly from the rearwardmost chamber 152b between the rear seat occupants' head and the vehicle side structure and thus may help move the rear seat occupant's head away from the side structure. The inflatable curtain 14b is thus deployed into the inflated condition wherein the curtain is positioned between the

front and rear seat occupants and the vehicle side structure.

5 The inflating curtain 14b thus moves the occupants' heads away from the vehicle side structure and the curtain inflates between the occupants and the vehicle side structure. The inflatable curtain 14b, when inflated, helps to protect the vehicle occupants in the event of a vehicle rollover or a side impact to the vehicle. The connections 70b help to limit the thickness
10 of the inflated inflatable curtain 14b and help to reduce the overall volume of the curtain. The front chamber 120b, middle chambers 100b, and rear chamber 150b, when inflated, help to absorb the energy of impacts with the inflatable curtain 14b and help to distribute the impact
15 energy over a large area of the curtain.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. For example, in the illustrated embodiments, separate connections define the front,
20 middle and rear chambers of the inflatable curtain. The front, middle and rear chambers could, however, be defined by any number of connections, including a single connection. Such improvements, changes and modifications

within the skill of the art are intended to be covered by the appended claims.